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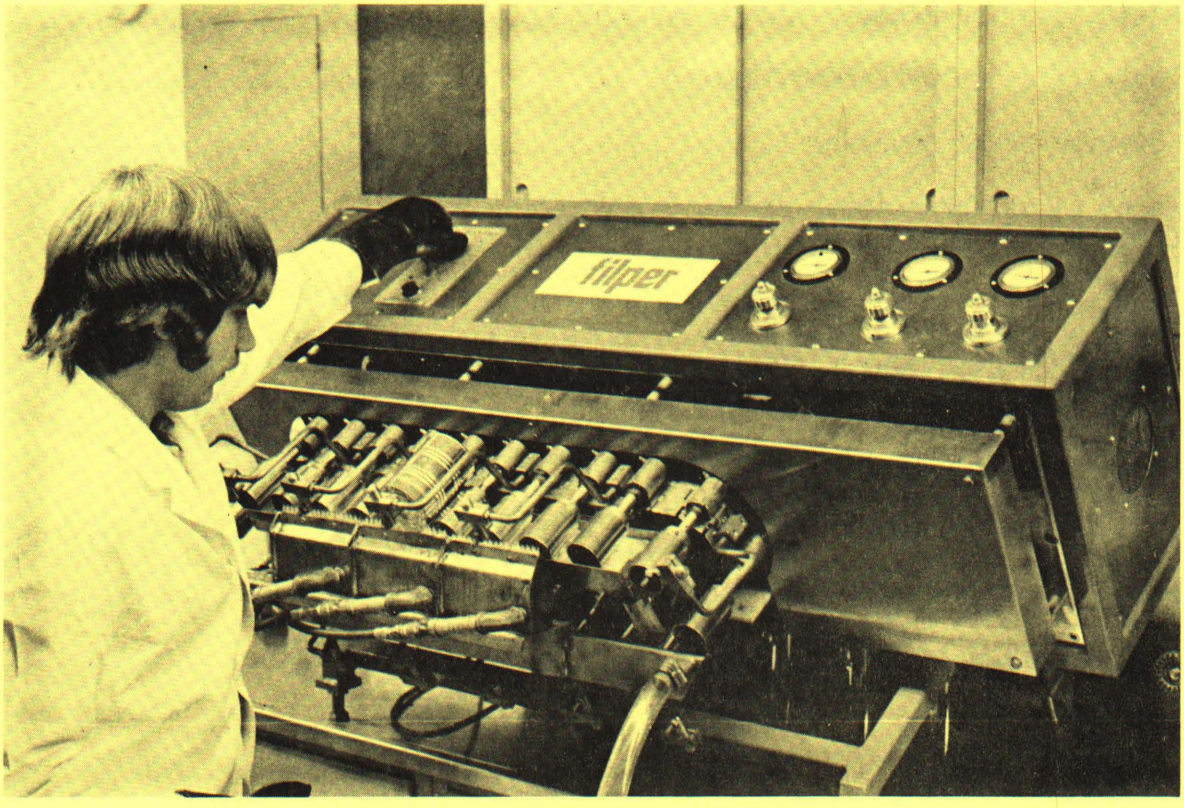
FRUIT AND VEGETABLE PROCESSING AND FOOD TECHNOLOGY



DEPARTMENT OF HORTICULTURE
The Ohio State University
Columbus, Ohio

and

Ohio Agricultural Research and Development Center
Wooster, Ohio

CONTENTS

ON THE COVER: Filper Steriflame Simulator, a recent addition to the Horticultural Processing Pilot Plant, is being used to study new techniques in food preservation.

EVALUATION OF SNAP BEAN VARIETIES FOR PROCESSING

by

W. A. Gould, J. A. Gould, J. L. Black, R. Stillabower and E. Korensky

Nine varieties of snap beans were grown on the Horticultural Farm at The Ohio State University. The beans were planted in 200 foot rows, 36 inches apart with the seed placed two to three inches apart in the row depending on seed size.

At harvest, the plants were pulled and the pods removed by hand. They were transported immediately to the Fruit and Vegetable Processing and Technology Pilot Plant. The beans were mechanically snipped, size graded, spray washed, water blanched and twelve ounces were hand packed into R enamel cans. Two size grades were used, 1-3 and 4-6 sieve sizes, the latter were cut into pieces 1 to 1½ inches long, the smaller size grade packed as whole beans. The beans were blanched, by sizes, using the continuous water blancher set at 175°F for 3 minutes. Both lots were water cooled prior to inspection and filling.

The canned snap beans were covered with boiling distilled water and a thirty-grain sodium chloride tablet was added to the can. The cans were exhausted for four minutes, steam flow closed (at 15 psi) and processed at 240°F and 10 psi for 20 minutes. They were water cooled to 100°F.

The frozen snap beans were filled into R enamel cans, steam flow closed, sealed, coded, frozen in a single contact freezer (-40°F) and stored at 0°F.

Quality was determined as follows (the results as reported in the following tables are the average values for all harvests where applicable):

Number of plants - The actual number of plants in 50 feet were pulled and counted for each of the harvests.

Yield - The beans were weighed to determine the gross yield in pounds for the number of plants in 50 foot rows and yield was calculated to ounces/plant.

Number of pods per pound - The number of pods in a one-pound field run sample was counted.

Percent sieve size - Sieve size was determined by measuring the diameter of the pod perpendicular to the sutures. The sieve sizes of a one-pound field run sample were determined and weighed. The data are shown by count, percentage by count and by weight for each sieve size.

Pod length - Pod length was determined by evaluating 20 pods as to average length reported in inches.

Percent by weight seeds - Determined on fresh, canned and frozen product and reported by sieve size. For determining percent by weight seeds, 100 grams of pods for each sieve size were deseeded and the seeds weighed.

Texture - Texture was determined on the GOSUT texturometer and the FTC instrument. On the GOSUT texturometer several pods of each sieve size were used to arrive at the average value. Results are reported directly in GOSUT texturometer values. On the FTC instrument the texture was determined at 150 psi, range of 3000 with 5 beans.

% Fiber - % Fiber was determined by the Official Food and Drug Method.

The grade of the canned and frozen products by the respective attributes of quality was determined in accordance with the U. S. Standards for Grades of Canned and Frozen Snap Beans. The actual score points assigned each of the attributes of quality are recorded by sieve size for each of the varieties.

Table 1 -- YIELD AND RAW PRODUCT QUALITY CHARACTERISTICS BY CULTIVAR AND SIEVE SIZE

Cultivar	No. Growing Days	No. Plants/100'	Yield Oz./Plant	No. Pods/lb.	Sieve Size	Count No./lb.	Count %	% by Weight	Ave. Length (in.)	GOSUT Texture	FTC Texture	% Fiber	% Seeds	Vitamin C
GP 467	65	270	1.8	95	1	235	18.4	8.0	2.8	1	13	.072	2.9	18.4
					2	150	15.8	10.2	3.7	4	28			
					3	107	16.5	15.6	4.1	9	26			
					4	81	31.2	38.7	4.5	11	38	.115	4.0	17.6
					5	59	11.5	16.4	5.0	12	54			
					6	54	6.5	10.3	5.3	14	44			
GP 563	67	265	1.6	128	1	312	19.8	7.6	2.6	0	15	.035	4.1	17.9
					2	174	16.6	11.8	3.3	5	23			
					3	132	15.2	14.3	3.5	8	28			
					4	113	15.0	16.5	3.5	10	33	.140	7.4	17.2
					5	90	17.2	23.4	4.0	17	49			
					6	79	16.2	26.2	4.3	19	48			
Early Gallatin	67	228	1.8	106	1	203	12.0	6.1	2.8	0	16	.070	2.9	15.7
					2	151	21.2	14.3	3.6	3	25			
					3	112	16.7	15.2	4.3	7	28			
					4	120	29.6	32.9	4.5	8	41	.073	4.2	15.1
					5	72	11.4	16.3	4.5	9	47			
					6	58	9.0	14.9	4.8	11	45			
GP 68-115	67	241	3.0	107	1	164	20.0	11.0	3.0	0	16	.055	4.1	17.9
					2	151	23.3	15.6	3.5	2	17			
					3	88	14.7	16.3	4.0	4	23			
					4	81	19.9	23.0	4.0	11	35	.090	3.8	16.9
					5	63	19.6	14.3	4.8	10	39			
					6	54	11.6	20.0	5.0	16	51			

Table 1 cont.

GP 66937A	70	308	2.2	110	1	278	21.5	7.7	3.1	2	17	.048	5.5	16.8
					2	142	13.4	10.8	3.5	5	22			
					3	111	19.2	17.2	4.3	9	27			
					4	84	25.4	29.8	4.8	13	38	.065	9.7	18.5
					5	63	10.3	16.3	5.0	13	49			
					6	55	10.0	18.0	4.8	18	81			
GP 317	72	251	1.9	123	1	259	20.1	7.9	2.9	0	15	.097	3.9	24.6
					2	150	15.2	11.9	3.7	6	20			
					3	106	16.2	16.6	4.3	9	29			
					4	83	23.9	29.7	4.6	15	38	.123	6.6	22.9
					5	72	11.0	15.1	4.6	20	49			
					6	63	13.4	17.8	4.9	14	56			
GP 65-71A	70	316	1.8	98	1	239	16.5	6.0	2.9	4	13	.090	4.3	24.0
					2	137	9.3	6.3	3.5	5	20			
					3	114	18.9	16.5	4.1	7	28			
					4	84	22.3	22.6	4.4	12	32	.125	5.2	19.5
					5	68	16.7	22.6	4.9	15	42			
					6	57	16.2	26.4	5.3	20	47			
GP 553	71	208	2.9	100	1	272	15.0	7.4	2.6	0	17	.085	3.3	21.7
					2	127	12.6	9.3	3.5	3	20			
					3	106	16.6	12.8	4.0	6	30			
					4	75	28.3	33.5	4.5	13	41	.175	7.2	20.7
					5	70	15.8	19.8	4.6	16	53			
					6	45	11.6	17.2	4.6	18	54			
Tendercrop	71	211	4.5	95	1	175	9.9	6.3	2.6	0	15	.045	6.5	18.3
					2	198	11.7	5.2	3.3	2	15			
					3	105	12.7	7.2	3.9	5	24			
					4	79	22.2	24.6	4.1	10	40	.112	6.7	16.8
					5	66	21.1	28.4	4.6	13	41			
					6	69	21.6	27.8	5.0	17	54			

TABLE II -- CANNED PRODUCT DATA

VARIETY	SIEVE SIZE	% SEEDS	% FIBER	LIQUOR	COLOR	DEFECTS	CHAR.	TOTAL SCORE	GRADE
GP 467	1-3	6.0	.035	10	14	32	38	94	A
	4-6	8.5	.070	9	14	32	35	90	B
GP 563	1-3	2.5	.048	10	15	32	39	96	A
	4-6	7.0	.110	9	14	32	36	91	A
Early Gallatin	1-3	1.2	.028	10	14	33	40	97	A
	4-6	4.4	.073	9	15	32	37	93	A
GP 68-115	1-3	1.8	.033	9	15	32	40	96	A
	4-6	3.0	.063	9	15	33	39	96	A
GP 66937A	1-3	6.5	.040	10	14	34	37	95	A
	4-6	7.2	.060	10	15	34	36	95	A
GP 317	1-3	3.0	.103	10	15	31	38	94	A
	4-6	8.5	.118	10	14	31	35	90	B
GP 65-71A	1-3	1.8	.070	10	15	32	39	96	A
	4-6	3.5	.083	10	15	34	38	97	A
GP 553	1-3	2.6	.063	10	15	32	39	96	A
	4-6	3.1	.085	10	15	34	39	98	A
Tender-crop	1-3	4.0	.113	10	14	31	38	93	A
	4-6	5.8	.098	8	14	33	37	92	A

TABLE III -- FROZEN PRODUCT DATA

VARIETY	SIEVE SIZE	% SEEDS	% FIBER	COLOR	DEFECTS	CHAR.	TOTAL SCORE	GRADE
GP 467	1-3	13.5	.085	19	39	34	92	B
	4-6	17.6	.060	20	37	31	88	C
GP 563	1-3	10.0	.060	19	38	34	91	B
	4-6	10.5	.085	19	39	34	92	B
Early	1-3	2.5	.103	20	37	40	97	A
Gallatin	4-6	4.0	.118	19	40	38	97	A
GP	1-3	14.9	.065	20	39	33	92	B
68-115	4-6	14.4	.105	19	39	33	91	B
GP	1-3	3.6	.020	19	36	38	93	A
66937A	4-6	6.7	.065	19	38	37	94	A
GP 317	1-3	3.6	.073	20	38	40	98	A
	4-6	6.2	.095	20	37	40	97	A
GP	1-3	2.8	.100	19	38	40	97	A
65-71A	4-6	5.0	.097	20	40	39	99	A
GP 553	1-3	4.2	.053	19	39	39	97	A
	4-6	5.8	.148	20	39	37	96	A
Tender-	1-3	4.1	.035	20	38	39	97	A
crop	4-6	6.8	.075	18	39	37	94	A

EVALUATION OF TOMATO CULTIVARS FOR PROCESSING

by

W. A. Gould, James Black, Emily Korensky, Ruth Stillabower,
Jacquelyn Gould and Jerry Wright

The 1973 processing tomato project included 12 cultivars of tomatoes which were grown in replicated plots under acceptable commercial practices at the Ohio Agricultural Research and Development Center - Northwestern Branch, Hoytville, Ohio. Each cultivar was machine harvested (with FMC Western Model) and bulk handled in 400 pound lots, either dry, or in water containing 500 ppm chlorine dioxide. Following harvest, the tomatoes were transported by truck (approximately 100 miles) to the Food Processing Pilot Plant at The Ohio State University, Columbus, Ohio for processing. All lots were processed after 12 hours hold following harvest as peeled whole tomatoes.

Quality Evaluation

A. Grade was determined on a 25 pound sample by segregating tomatoes for color, defects and culls.

B. Size was determined by counting the number of fruits in the 25 pound sample. In addition the tomatoes were subjectively classed for shape, fruit surface, core, firmness and type of defects.

C. Twenty field run tomatoes were selected and used for objective quality evaluation:

1. Stem scar length, stylar scar length, stem length and wall thickness were determined by measuring the average length in inches.

2. % Red Color was determined by counting the number of tomatoes in the sample that had full red color.

3. E-5 cut surface color was determined on an Agtron E-5 instrument after making a crosswise cut in the tomato and reading the values after standardization at 48.

4. The sample was then quartered, extracted in a Food Processing Equipment Co. Laboratory pulper and deaerated.

   a. The sample was evaluated for color with the Hunter Color and Color Difference Meter using the wide area illuminator and large aperture. The instrument was standardized with the "Red" tile with L = 25.59, aL = 27.40, and bL = 12.54.

b. The pulp was presented to the Agtron E-5 instrument in a standard plastic sample sup with the instrument calibrated at 48. The color reading was taken directly and recorded as such.

c. Percent soluble solids. An Abbe refractometer was used for direct determinations of percent soluble solids on raw and canned juice. The instrument was standardized with distilled water and all readings converted to 20°C.

d. pH. The pH was determined by the glass electrode method (Beckman Zeromatic pH meter) using 10 ml of tomato juice (raw or canned) diluted with 90 ml of distilled water.

e. Percent total acid as citric. The sample used for pH determination was directly titrated using 0.1 normal sodium hydroxide solution to a pH of 8.1. Calculations using the following equation were made:

$$\% \text{ acid} = \frac{(\text{No. of ml of } 0.1\text{N NaOH}) \ (.0064)}{10 \text{ ml sample}} \times 100$$

f. Ascorbic Acid. 10 ml aliquots of tomato juice were diluted with 90 ml of 1% meta phosphoric acid and filtered. A 10 ml aliquot of the filtrate was titrated with 0.2% 2,6-dichlorophenolindophenol indicator solution. Milligrams of Vitamin C were determined by the following formula:

$$\text{Dye factor} \times \text{ml of dye} \times 100 = \frac{\text{mg Vit. C}}{100 \text{ g}}$$

D. Grades of Canned Tomatoes. The grade was determined in accordance with the U. S. Standards for Grades of Canned Tomatoes.

Preparation and Processing

All tomatoes were prepared by washing, lye peeling (18% caustic soda and Faspeel at 200°F for 20 to 30 seconds) and processed as whole tomatoes. Each lot of whole tomatoes was filled to 10.5-11.0 ounces in No. 303 fruit enamel tin cans with a 30-grain salt tablet (21 grains Sodium and 9 grains Calcium Chloride) added. The product was processed at 220°F for 20 minutes, water cooled and warehoused for 3 months prior to grading.

The data in Table I summarize the results. Vermillion was the largest fruit with excessive cracking and generally a poor looking fruit from the standpoint of color. Not recommended for canning. Chef was also a large fruit and showed very poor in the can. However, it was a good peeler. Not recommended for canning.

The best cultivars in the trial were 03070, Lafayette, 01970, 013071 and Dorchester. All are recommended for further trials or production in Ohio. Dorchester is the only cultivar in these trials that could be canned without acidification.

Cultivars AC19271, 016371, Caroline, Arc and 02970 showed an average quality. Caroline is the smallest fruit size of any (322/25 pounds) and with exception of lack of fancy color has good possibilities as a machine harvest mechanical peel cultivar.

TABLE I -- TOMATO CULTIVAR EVALUATION

	01970	03070	013071	Vermillion	AC19271	016371
Raw						
Fruit Shape	Globe	Globe	Globe	Flat	Oblong	Globe
Fruit Surface	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Fruit Size	Small	Med.	Small	Large	Small	Small
Diameter (in)	-	2 1/16	2	2 3/4	1 3/4	2 1/4
Length (in)	-	2	1 7/8	2	1 3/4	1 3/4
Ct./25 lb.	140	148	175	96	186	159
Stem Scar (in)	3/8	3/8	3/8	3/4	3/8	3/8
Stylar Scar (in)	1/8	none	none	3/8	none	1/8
Stem Length (in)	1/8	3/8	3/8	1/2	1/4	none
Firmness	Hard	Med.	Soft	Med.	Med.	Med.
No. Locules	6	4	3	8	5	5
Wall Thick. (mm)	-	1/4	1/4	3/16	1/4	1/4
Core	-	Small	Small	Small	Med.	Med.
Type of Defects (Cracks)	none	30%	35%	95%	20%	Cracks
% Red Color	50	80	70	25	65	50
E5 Cut Surface	-	35	39	32	45	46
E5 Pulp Color	35	33.5	36.5	40	43.5	41
Hunter L	28.8	27.1	28.7	26.9	31.7	29.7
a	33.8	35.9	32.7	31.5	34.8	35.2
b	13.8	13.2	13.5	11.8	15.5	14.7
a/b	2.44	2.71	2.42	2.66	2.24	2.39
pH	4.45	4.42	4.42	4.36	4.35	4.38
%TA as citric	.31	.29	.33	.29	.35	.33
%SS	5.00	4.4	5.00	5.20	4.80	5.1
Vit.C mg/100 mg	29.28	26.4	26.4	22.5	24.0	25.44
Canned						
Drained Wt. (20)	18	20	17	18	17	17
Wholeness (20)	19	20	19	18	20	18
Color (30)	27	28	27	26	26	25
Defects (30)	30	28	28	29	28	28
Total (100)	94	96	91	91	91	88
Grade	A	A	A	B	B	B
pH	4.2	4.3	4.2	4.26	4.2	4.16
% TA as citric	.45	.45	.46	.45	.45	.48
Count/303	5.5	5.5	6	5	6.5	6
Cored	Yes	No	No	Part	Part	No
Comments:	Good Peel	--	Excell. Peel, Good Looking	Looks Poor	Good Peel	Poor Peel

	Dorchester	Lafayette	Chef	Caroline	Arc	02070
Raw						
Fruit Shape	Pear	Globe	Globe	Globe	Globe	Globe
Fruit Surface	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Fruit Size	Small	Med.	Med.	Small	Small	Med.
Diameter (in)	1 3/4	2 1/8	2 1/4	1 1/2	2	2 1/4
Length (in)	2 1/2	1 3/4	2	1 5/8	1 7/8	1 3/4
Ct/25 lb.	196	169	138	322	157	140
Stem Scar (in)	3/8	3/8	3/8	1/4	3/8	3/8
Stylar Scar (in)	none	1/8	1/8	none	1/8	3/8
Stem Length (in)	3/8	3/8	5/8	1/4	1/2	3/8
Firmness	Med.	Med.	Med.	Hard	Hard	Med.
Locules No.	3	4	5	3	5	7
Wall Thick (mm)	3/16	1/4	3/16	1/4	1/4	1/8
Core	Med.	Med.	Med.	None	Small	Small
% Cracks	55	15	55	25	5	40
% Red Color	85	75	30	80	80	60
E5 Cut Surface	44	39	--	--	35.5	37
E5 Pulp Color	35	37	37	56.5	37.5	37
Hunter L	28.8	28.9	28.8	29.3	29.0	29.2
a	34.4	35.5	34.1	32.6	35.9	33.8
b	13.8	13.7	14.2	14.2	14.1	13.3
a/b	2.49	2.59	2.40	2.29	2.54	2.54
pH	4.35	4.41	4.42	4.4	4.32	4.5
%TA as citric	.44	.31	.32	.33	.33	.35
%SS	4.9	4.4	4.5	4.6	5.1	5.2
Vit C mg/100 mg	23.2	28.8	30.7	20.16	23.5	26.4
Canned						
Drained Wt. (20)	16	20	20	20	18	20
Wholeness (20)	20	20	19	20	19	20
Color (30)	28	28	22	26	22	25
Defects (30)	27	30	30	30	27	30
Total	91	96	91	95	86	95
Grade	A	A	C	B	B	B
pH	4.24	4.2	4.19	4.27	4.22	4.2
%TA as citric	.40	.47	.45	.47	.45	.5
Count/303	5	6	6	11.5	5.5	6.5
Cored	Yes	Yes	Yes	Part		Yes
Comments:	Poor peeler	Good peeler	Good peeler 50% jointless	Good peeler		Good peeler

OBJECTIVE EVALUATION OF COMMERCIAL TOMATO JUICE

by

Kenneth L. Beck and W. A. Gould

Commercial tomato juice was collected throughout the Columbus area from October 15, 1973 to November 15, 1973. The samples were objectively evaluated for percent soluble solids, pH, total acid, color and viscosity. Data were analyzed and frequency distribution curves were plotted for each attribute.

Objective Evaluation

1. Percent soluble solids -- An Abbe refractometer was used for direct determinations of percent soluble solids on the samples. The instrument was standardized with distilled water and all readings converted to $20^{o}C$.

2. pH -- The pH was determined by the glass electrode method (Beckman Zeromatic pH meter) using 10 ml of tomato juice diluted with 90 ml of distilled water.

3. Percent total acid as citric -- The sample of juice for the pH determination were directly titrated using 0.1 normal sodium hydroxide solution to a pH of 8.1. Calculations using the following equation were made:

$$\% \text{ acid} = \frac{(\text{No. of ml of 0.1N NaOH})\ (.0064)}{10 \text{ ml sample}} \times 100$$

4. Viscosity -- The viscosity was measured using the GOSUC efflux tube instrument (a 5/64" opening and standardized at 32 seconds at $25^{o}C$ with water). The rate of flow from the instrument was measured with a stop watch and the readings were recorded directly in seconds.

5. Color -- The samples were evaluated for color with the Hunter Color and Color Difference Meter using the wide area illuminator and large aperture. The instrument was standardized with the "Red" tile with $L = 25.59$, $a_L = 27.40$ and $b_L = 12.54$. The color was expressed in terms of the a_L/b_L ratio.

Discussion

1. Percent soluble solids -- The data in Figure 1 shows a near normal curve for percent soluble solids of these samples of commercial tomato juice. Approximately 68% of the samples range from 5.49 to 6.69 with an average of 6.09.

2. pH -- The data in Figure 2 shows a near normal curve for pH of these samples of commercial tomato juice. Approximately 68% of the samples range from 4.28 to 4.48 with an average of 4.38. This is due largely to the raw product.

3. Percent total acid -- The data in Figure 3 shows a near normal curve for total acid of these samples of commercial tomato juice with 68% of the samples ranging from .31 to .41% total acid.

4. Viscosity -- The data in Figure 4 indicates a wide range of viscosity in commercial tomato juice. Within one standard deviation the range was from 42.09 to 82.30 with an average of 62.43. This is due mainly to the processing variations in unit operations encountered by commercial processors, such as, the type of "break" used and the extent of the extraction process.

5. Color -- The data in Figure 5 indicates the a_L/b_L values showing a wide range of color in the samples of commercial tomato juice. Sixty-eight percent of the samples fall between 1.56 and 1.90 with an average of 1.73. The two peaks may indicate the separation between fancy and standard juice. A value of 1.65 (first peak) would be considered standard, while a value of 1.80 (second peak) would be considered fancy for color grade.

Figure 1 - Frequency Distribution of % Soluble Solids of Commercial Tomato Juice

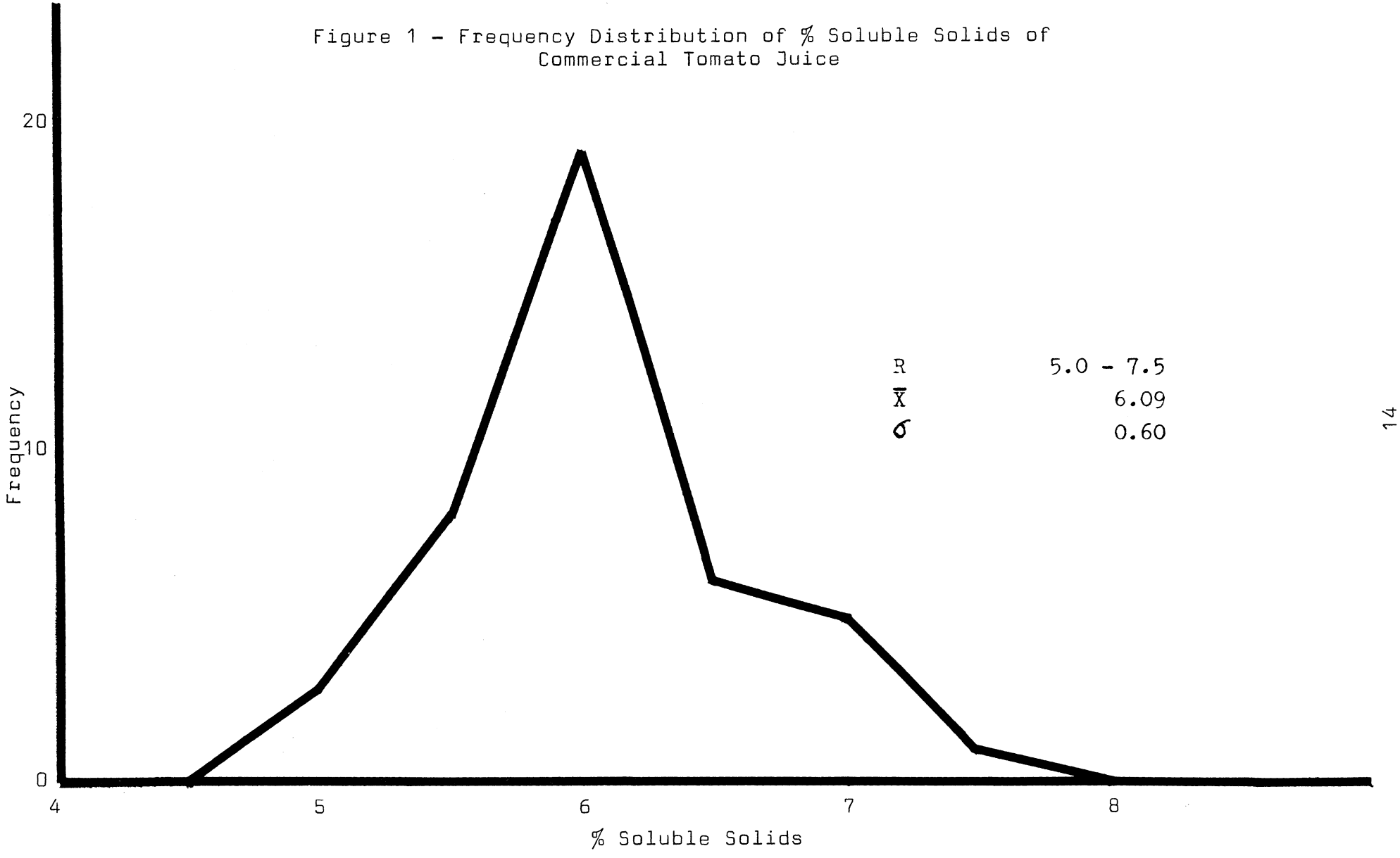


Figure 2 - Frequency Distribution of pH of Commercial Tomato Juice

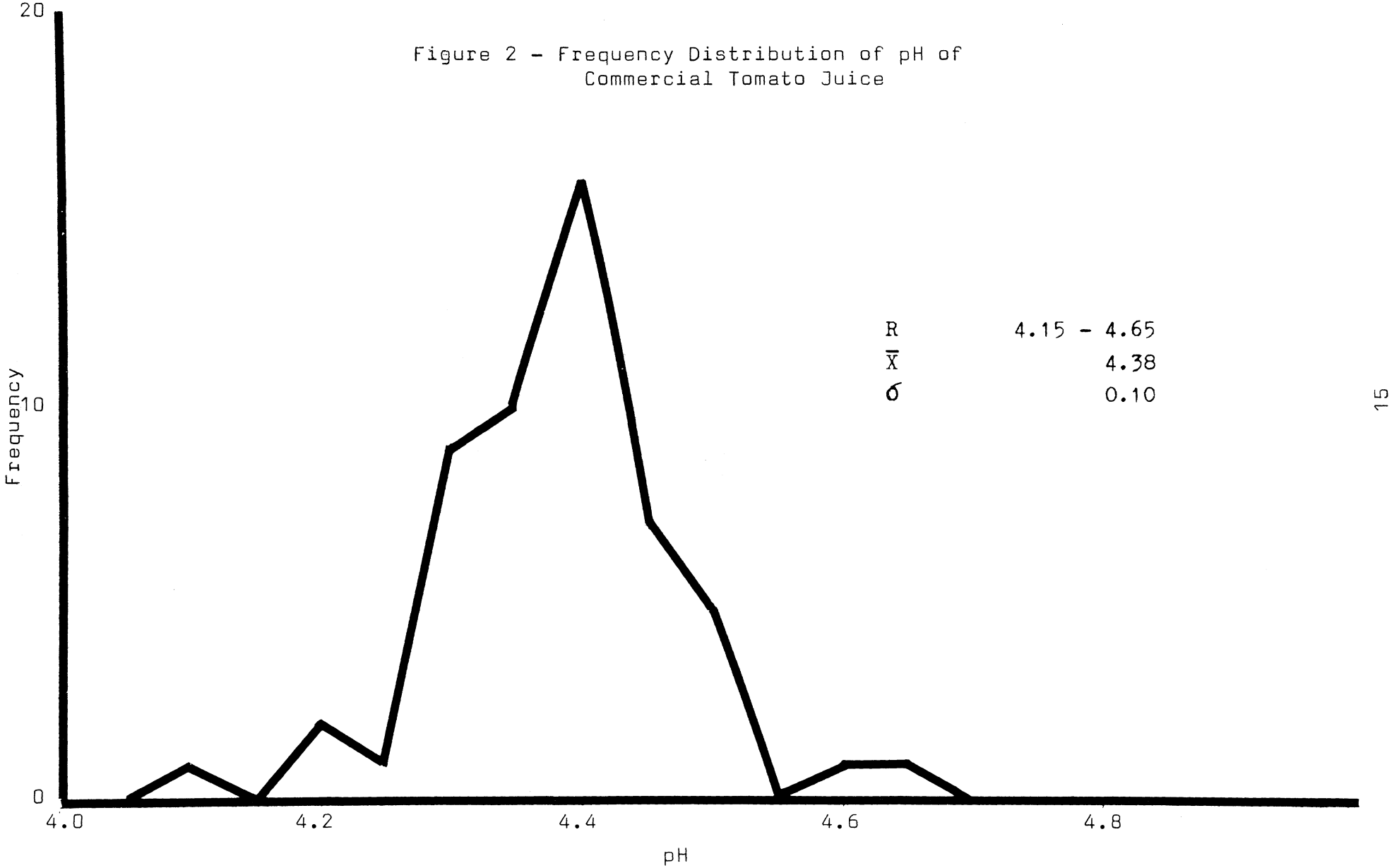


Figure 3 - Frequency Distribution of % Acid as Citric of Commercial Tomato Juice

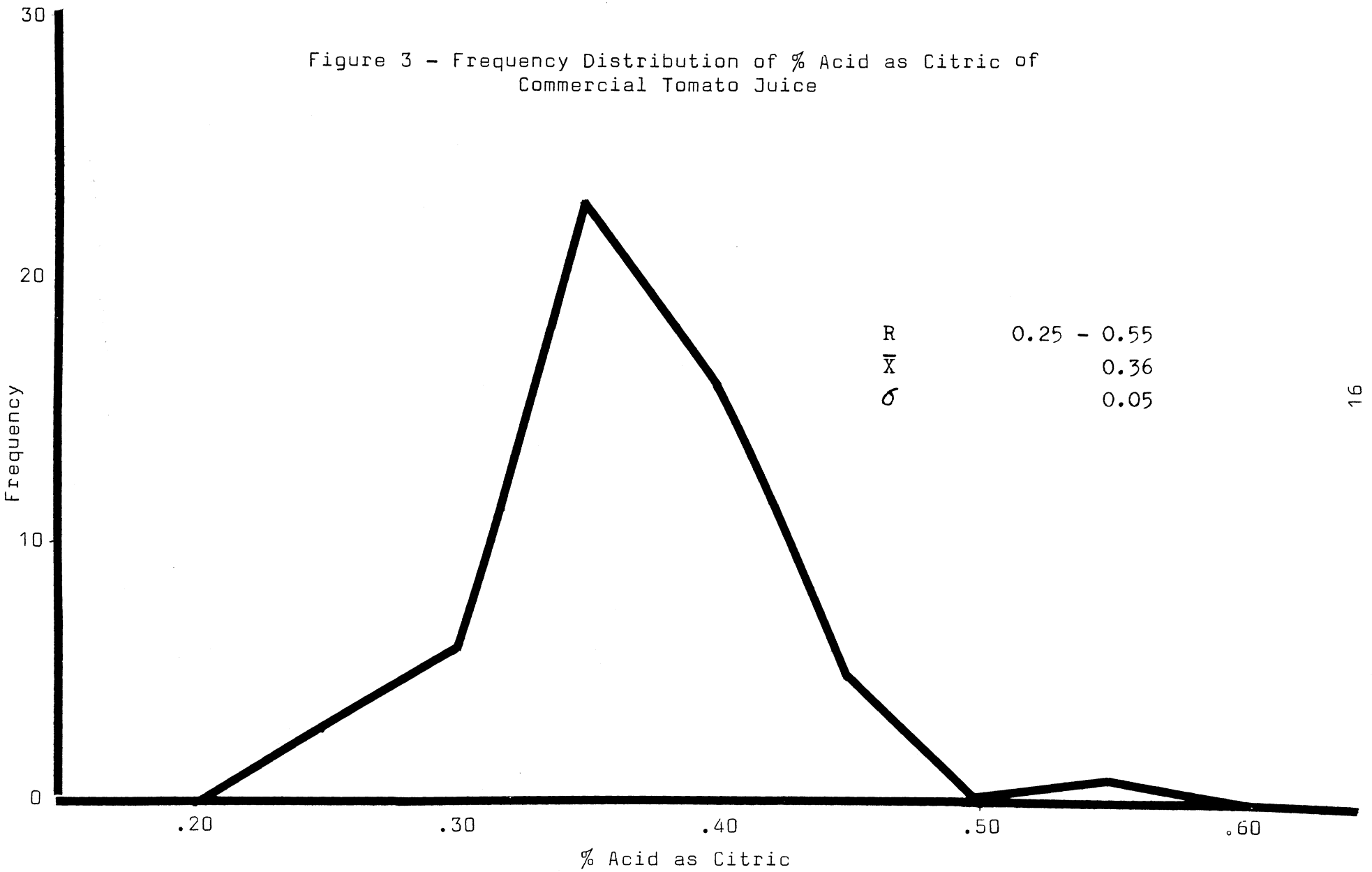


Figure 4 - Frequency Distribution of Viscosity of Commercial Tomato Juice

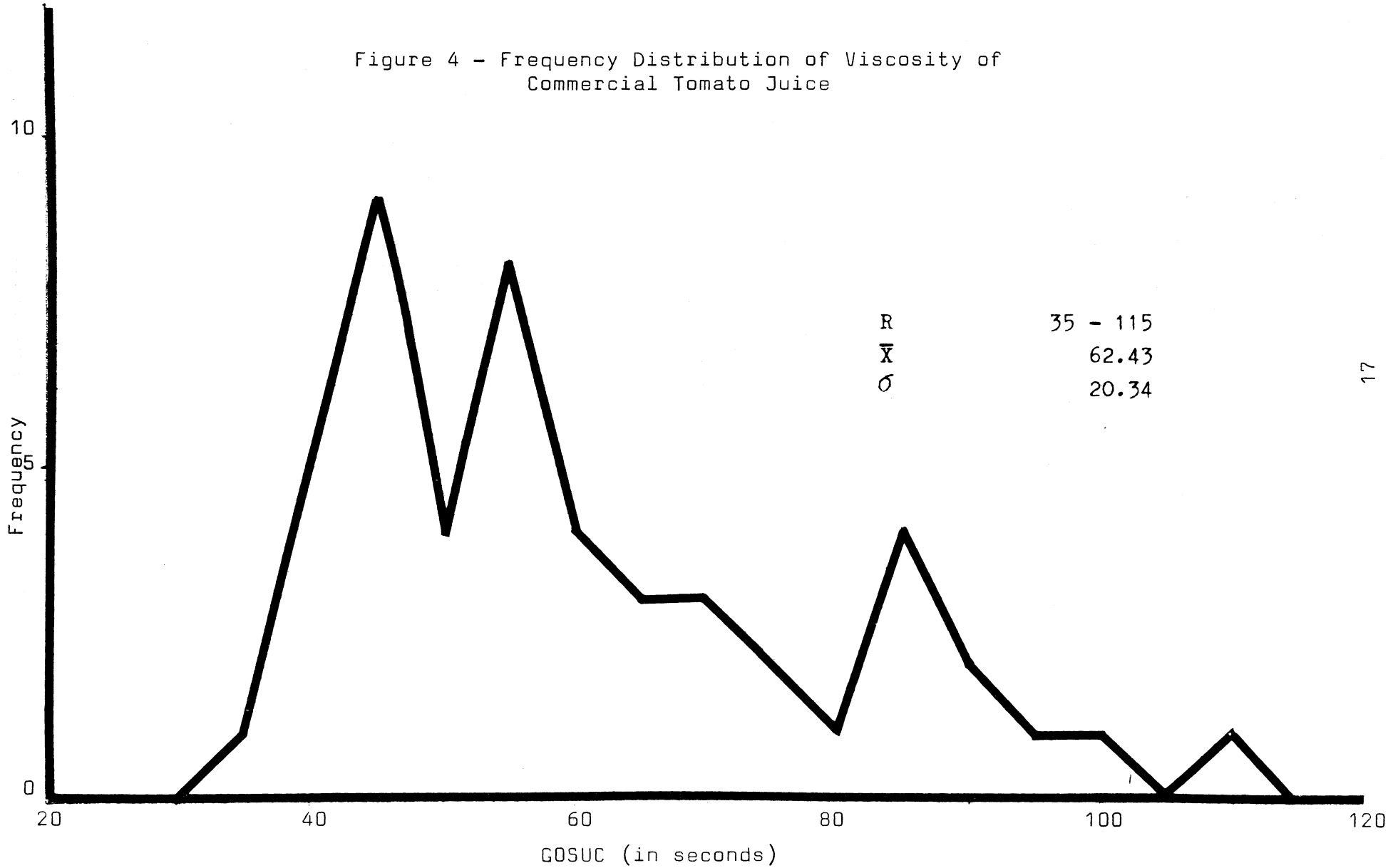
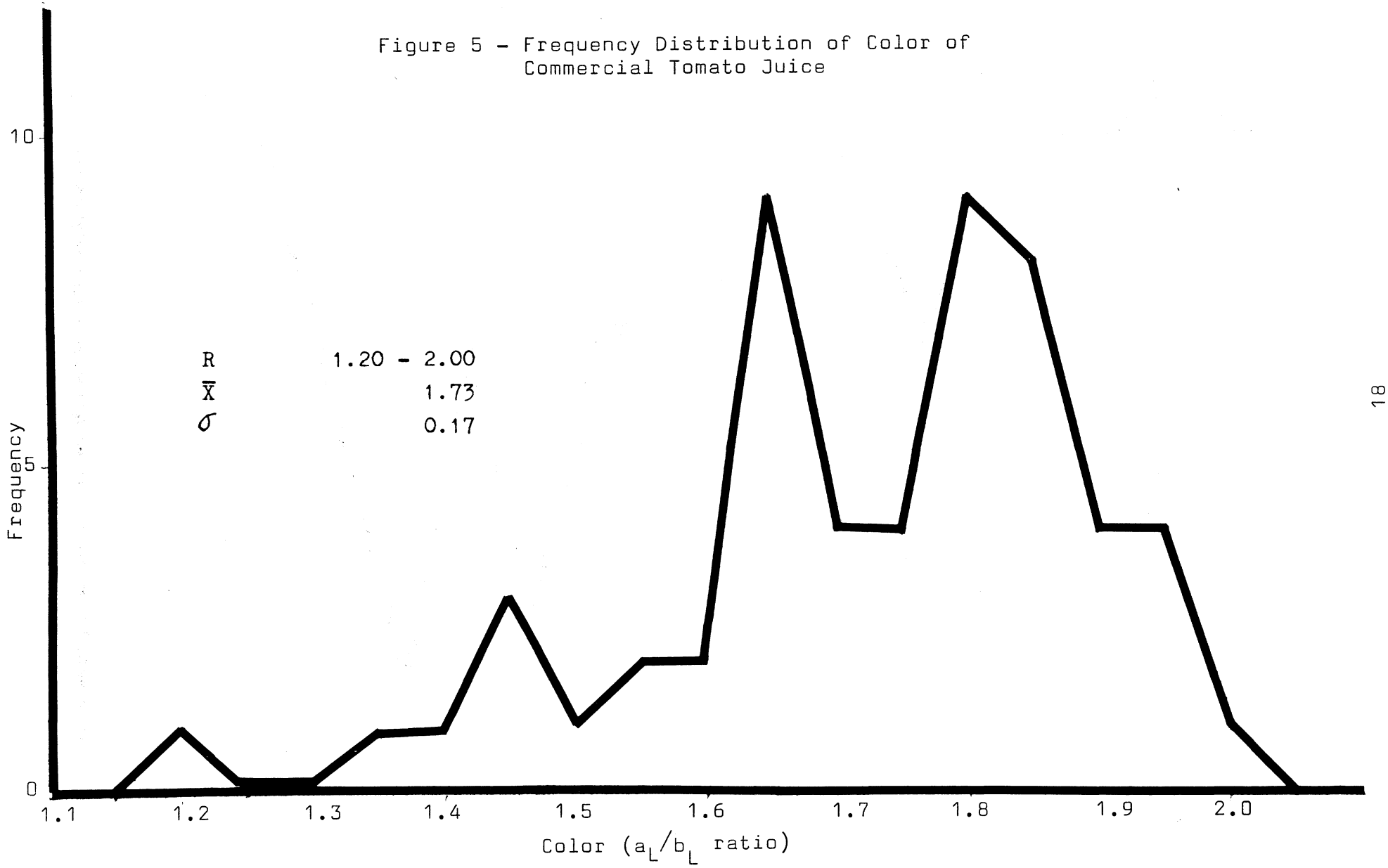


Figure 5 - Frequency Distribution of Color of Commercial Tomato Juice



THE EFFECT OF TIME AND TEMPERATURE UPON THE COLOR OF TOMATO JUICE

by

Gary Flinn and W. A. Gould

A study of the effects of time and temperature on the color of tomato juice was conducted. Fourteen lots of tomatoes grown under accepted cultural practices at the Ohio Agricultural Research and Development Center, Northwestern branch, Hoytville, Ohio were used in this study. The tomatoes were processed into juice at The Ohio State University Food Processing Pilot Plant. After processing, the samples of juice were stored at 35°, 55°, 68° and 88°F. Objective color measurements were made using the Hunter Color and Color Difference Meter at 3, 6, 9 and 12 months.

The initial color of all samples before storage was U. S. Grade A as determined by the a/b ratio and the Hunter-Munsell Chromaticity Diagram. Thus, it should be kept in mind that the conclusions of this study are based on an initial high color score.

The data in Table 1 shows the effect of time and temperature upon the color of tomato juice as measured by the a/b ratio. A graphic representation of the data is shown in Figure 1.

The following conclusions are drawn from this study.

1. Storage temperature of 88°F significantly reduced the color of tomato juice over all periods of storage.

2. A time-temperature interaction significantly contributed to the degradation of tomato juice color at temperatures of 55° and 68°F for storage periods longer than nine months, and at 88°F for periods longer than three months.

3. Although the effect of time and temperature significantly contributed to the deterioration of tomato juice color, a storage temperature of 88°F for twelve months was necessary to produce a tomato juice color which was U. S. Grade C for color as determined by Hunter-Munsell Chromaticity Diagram.

Reference

Flinn, Gary L. The Effect of Time, Temperature and Level of Ascorbic Acid Fortification on the Color of Tomato Juice. Ph. D. Dissertation. The Ohio State University. 1973.

Table 1

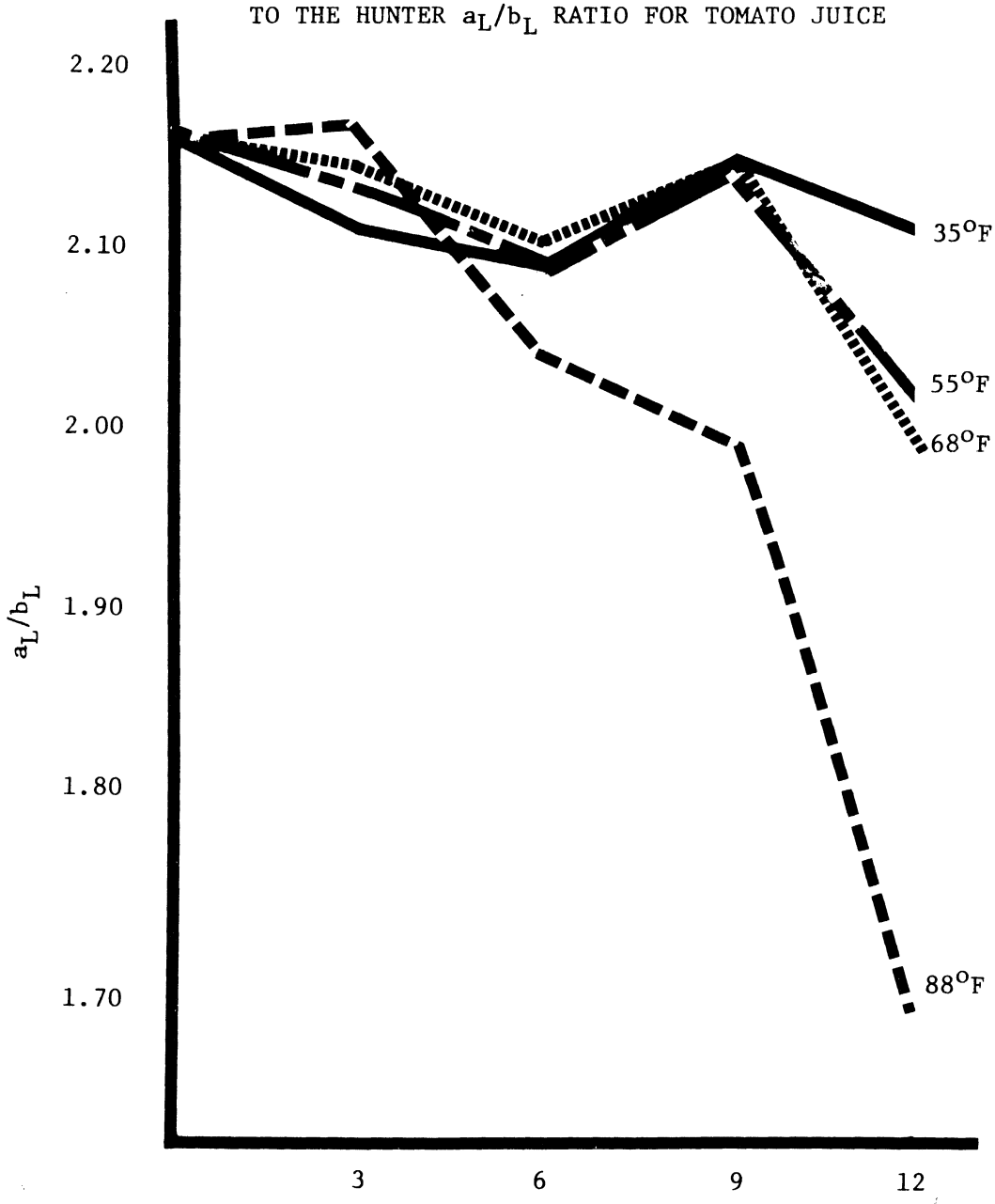
THE EFFECT OF THE TIME x TEMPERATURE INTERACTION ON THE COLOR OF TOMATO JUICE AS EXPRESSED BY THE HUNTER a_L/b_L RATIO

Storage Temperature °F	Storage Time in Months (Hunter a_L/b_L Ratio)				
	0	3	6	9	12
35	2.16	2.12	2.10	2.16	2.12
55	2.16	2.14	2.10	2.15	2.02
68	2.16	2.15	2.11	2.16	2.00
88	2.16	2.12	2.05	2.00	1.68

L.S.D. at the one percent level = 0.071

Figure 1

RELATIONSHIP OF THE TIME X TEMPERATURE INTERACTION TO THE HUNTER a_L/b_L RATIO FOR TOMATO JUICE



FLAME STERILIZATION PROCESS FOR CANNED FOODS

by

R. L. Joseph, L. A. Riegel and W. A. Gould

BACKGROUND

Flame sterilizer is an apparatus in which hermetically sealed containers are agitated at atmospheric pressure, by either continuous, discontinuous, or reciprocating movement, over gas flames to achieve sterilization temperatures. A holding period in a heated section may follow the initial heating period.

This is the principle and operation of the flame sterilizer, a machine which promises remarkable production throughput capacity and intriguing product development potential. The concept of flame sterilization of canned foods stems from a search by Cheftel and Beauvais, two French inventors, for an alternative to high pressure steam processing. After experimenting with and discarding infrared generators and hot air systems, they developed and in 1963 patented their "Sterilizing Method for Canned Foodstuffs" (U.S. Patent 3,071,478).

CURRENT USE

Presently some 70 flame sterilizers are in use world-wide, primarily in France and other European countries. Of the nine machines in use in the United States, eight are used by mushroom processors, who have experienced less product shrinkage with the higher temperature, shorter time process. The ninth is being used for whole tomato processing in California, where improvements in color, wholeness and drained weight are reported.

PRINCIPLE OF OPERATION

Heat is applied by direct flame contact on the surface of the rotating cans. The patent holders originally reported that the infrared radiation generated by the flame readily passed through the bright tinplate to rapidly heat the products contained within. In any event, the large temperature differential between the flame at 1800-2400°F when combined with agitation of the contents, results in a heating curve that is nearly straight-line with a steep slope on arithmetic graph paper.

When particulate products canned in liquid are agitated by rotation in the range of 20-250 revolutions per minute, remarkably uniform product temperatures throughout the container are obtained. This is demonstrated by measuring internal can temperature with a thermocouple while simultaneously measuring can surface temperature at various points with a pyrometer.

LABORATORY APPARATUS

A laboratory model flame sterilizer, manufactured by Filper Corporation, American distributors of the French Steriflamme, is presently being used for experimental work in the Food Processing and Technology Pilot Plant at The Ohio State University. Like the full scale production machines, the laboratory model is designed with the following variables:

1. Flame temperature is controlled by regulators on gas flow rate and pressure.

2. Can exposure time to the flame is controlled by a variable speed push-bar conveyor.

3. Can rotation speed is varied by changing the speed of the conveyor on which the can rests.

The rotating cans are cooled quickly by water spray following the process.

PROCESSING CONSIDERATIONS

With no counterbalancing external steam or air pressure during heating as in conventional retort processing, the can itself becomes a pressure vessel, which undergoes increasing stress as product temperature rises. To reduce the liklihood of permanent distortion or "buckling" of the can ends due to internal pressure buildup in excess of the can structure tolerance, the following preventive measures may be required:

1. Blanching of vegetables to reduce amounts of entrapped gases.

2. Filling of can to maximum extent possible to reduce headspace.

3. Closing cans at highest possible temperature.

4. Avoiding excessive can sterilization temperature.

5. Selecting can ends with adequate tinplate thickness and flexibility.

STEAM PREHEAT AND STERILVAC

To obtain uniform sterilization temperatures among all cans under a given set of processing conditions, the initial temperature of all cans must be uniform (Fig. 3). Two devices which have been used in conjunction with the steriflamme to equalize initial temperatures are the steam preheater and the sterilvac.

The steam preheater may be incorporated as a part of the steriflamme equipment. By rotating the sealed can on a track through atmospheric steam, rapid heating to temperatures near that of the steam is obtained. This method is applicable to nearly all products which may be flame sterilized.

The above Frenchmen also developed a sterilvac unit which heats the product packed in small quantities (1-4%) of sauce or brine in a container with a clinched lid. The can is agitated at an angle over direct flame for 3-7 minutes, generating steam from the liquid which preheats the product and expells the air. The can is immediately seamed to assure a reasonably uniform temperature and high vacuum. The cans are then flame sterilized to complete this variation of the "vac-pac" process.

POTENTIAL USES AND LIMITATIONS

The sterilvac and steriflamme units appear to have great potential in the processing of fruits and vegetables, including sirup or brine pack and vac-pac products. Although many solid pack or highly viscous products, such as pumpkin or meat products, may not be feasibly processed by direct flame, the use of controlled viscosity starches offers expanded opportunities for development of flame sterilized products.

ECONOMIC CONSIDERATIONS

Beauvais (1973) cites several economic and efficiency advantages of the steriflamme over conventional processing equipment.

1. Simplicity of operation translates to lower equipment costs.

2. Straight-through design leads to less wear and tear on machine parts, resulting in lower maintenance costs.

3. Several can sizes may be processed on the same unit, obviating the need for specialized equipment for each can size.

4. Energy is not lost through intermitent heating and cooling of retort baskets or the sterilizer itself.

Alternate fuels are being sought to replace the fossil fuel gases which are presently required for operation and which are increasing in cost. However, it should be noted that the same fuels are often used in conventional processes to generate steam.

SUMMARY

Direct flame may be used to rapidly reach sterilization temperature and thermally process certain canned fruits and vegetable products. Strict process control must be exercized to assure product safety and to optimize quality.

FLAME STERILIZATION OF CANNED TOMATOES

by

L. A. Riegel, R. L. Joseph and W. A. Gould

The objective of this study was to determine time-temperature relationships sufficient to effect sterilization without burning or impairing the product.

The primary variables of the flame sterilizer are:

1. Can rotation rate,
2. Time of can exposure to the flame, and
3. Gas flame temperature.

Experiments involving the variation of the can rotation rate included changes in fill weight, tomato size, methods of obtaining vacuum and can exposure time over the flame. The following are four of the basic studies underway.

1. Heat Penetration - The time of can exposure to the flame was varied from two to three minutes for each rotation rate, with the temperature of the outside of the can determined with the aid of a pyrometer.

2. Tomato Size - The time of can exposure to the flame was kept constant, with the can rotation and the size of tomatoes varying. Cored and uncored tomatoes were also used to determine effects, if any, of flame sterilization on the cored and uncored tomatoes of three sizes.

3. Vacuumizing Techniques - Methods of obtaining a vacuum and rotation of the closed can were varied with time over the flame and fill weight constant.

4. Fill Weight - Various fill weights for given can rotation speeds were used with the time, the exhaust temperature and the flame temperature held constant.

PROCEDURE

The procedure for each of the experiments was essentially the same. The time the can was on the burner and the flame temperature settings were constant throughout all the tests except for the heat penetration experiments. In the latter case the time was varied. The heat penetration tests involved keeping all variables the same except the time factor which was varied from two to four minutes to give a relationship with the rise in temperature per unit time. In the other experiments, the time of can exposure to the flame was 4 minutes and 45 seconds on all three burner sections.

The burner gauge readings were as follows:

	Burner Settings		
	No. 1	No. 2	No. 3
Gas Pressure	6.05	6.80	6.25
Gas Flow Rate	13.10	6.00	5.30

The pressure and the flow rates were arbitrarily chosen to give the best possible flame arrangements for maximum heating. The rotations of the cans were varied for all of the experiments. Three replicate cans were used for each of the various experiments.

RESULTS

In the heat penetration experiments, the slope of the straight line (Temperature versus Time on semi-logarithmic paper) gives the heating rate of the process. For the given conditions of this experiment, the maximum heating rate occurs when the can is rotating at approximately forty revolutions per minute. The can's optimum rotational speed increases as the temperature of the flame increases.

For the experiment of varying fill weights for tomatoes the results showed an increase in temperature with time as the fill weight increased. The maximum temperature was achieved with can fill weights of eleven ounces. The maximum temperature was reached at forty revolutions per minute as shown in Figure 2.

When the tomato size was the variable, the highest temperature was obtained with larger sized tomatoes. (See Figure 2.) Maximum heat penetration occurs at 40 can revolutions per minute for all fill weights, although statistically, the difference between 30-40 rpm may not be significant.

Figure 1

TEMPERATURE X CAN ROTATION FOR PROCESSING WHOLE TOMATOES

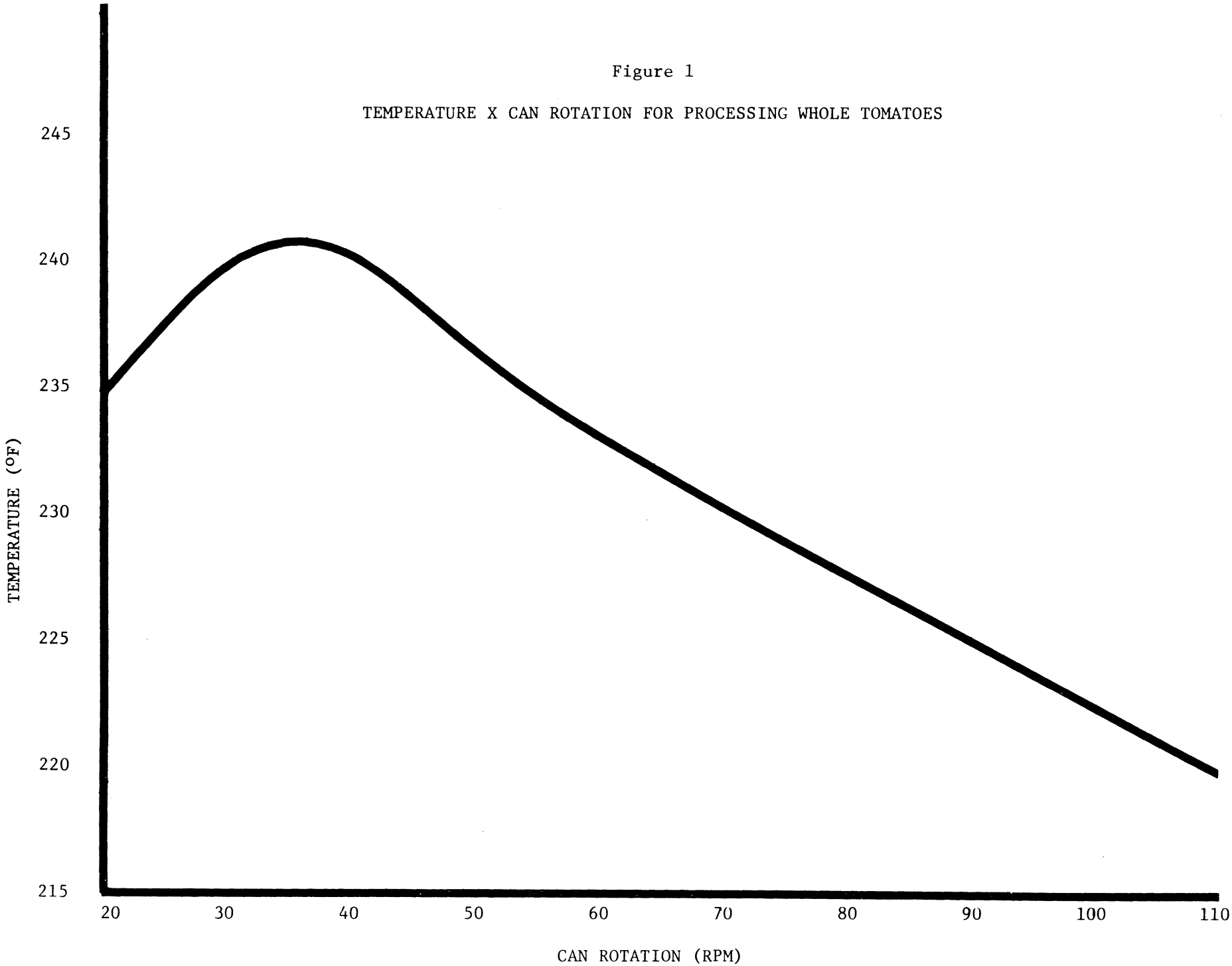


Figure 2

AVERAGE TEMPERATURE X CAN ROTATION FOR VARIOUS FILL WEIGHTS

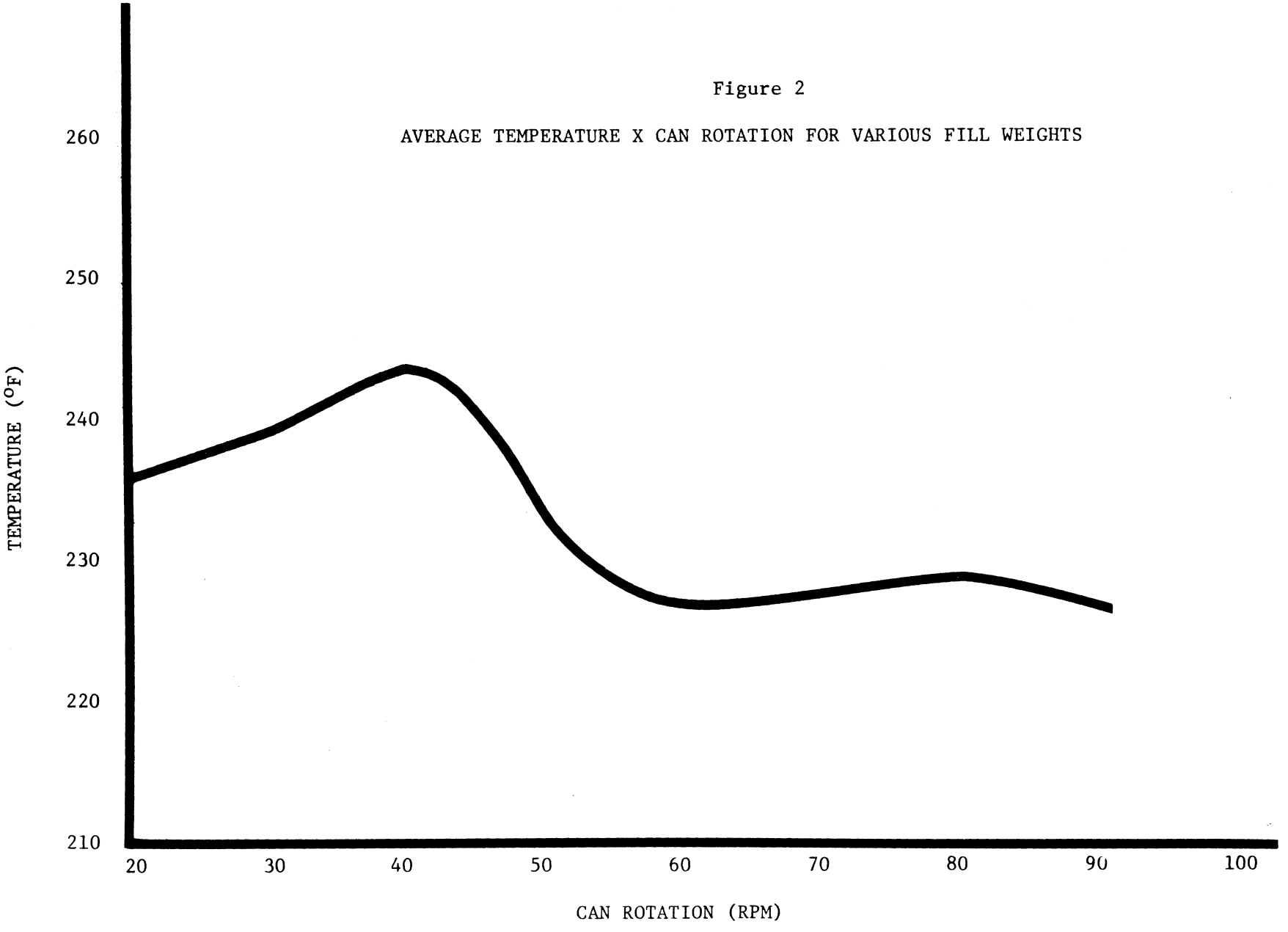


Figure 3

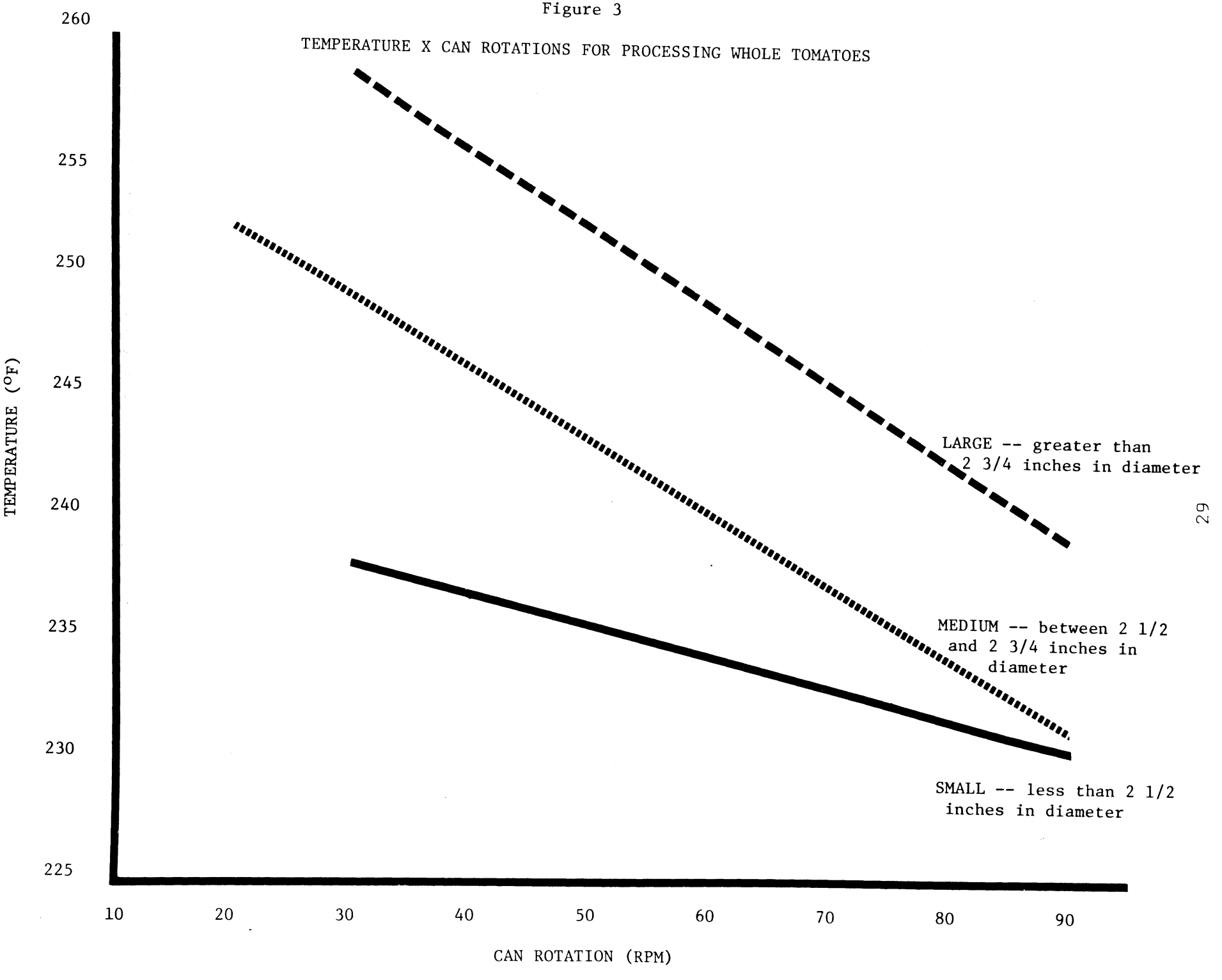

TEMPERATURE X CAN ROTATIONS FOR PROCESSING WHOLE TOMATOES
260
255
250
245
240
235
230
225
TEMPERATURE (°F)
LARGE -- greater than 2 3/4 inches in diameter
MEDIUM -- between 2 1/2 and 2 3/4 inches in diameter
SMALL -- less than 2 1/2 inches in diameter
10
20
30
40
50
60
70
80
90
CAN ROTATION (RPM)

Figure 4

TEMPERATURE X CAN ROTATION FOR PROCESSING TECHNIQUES FOR WHOLE TOMATOES

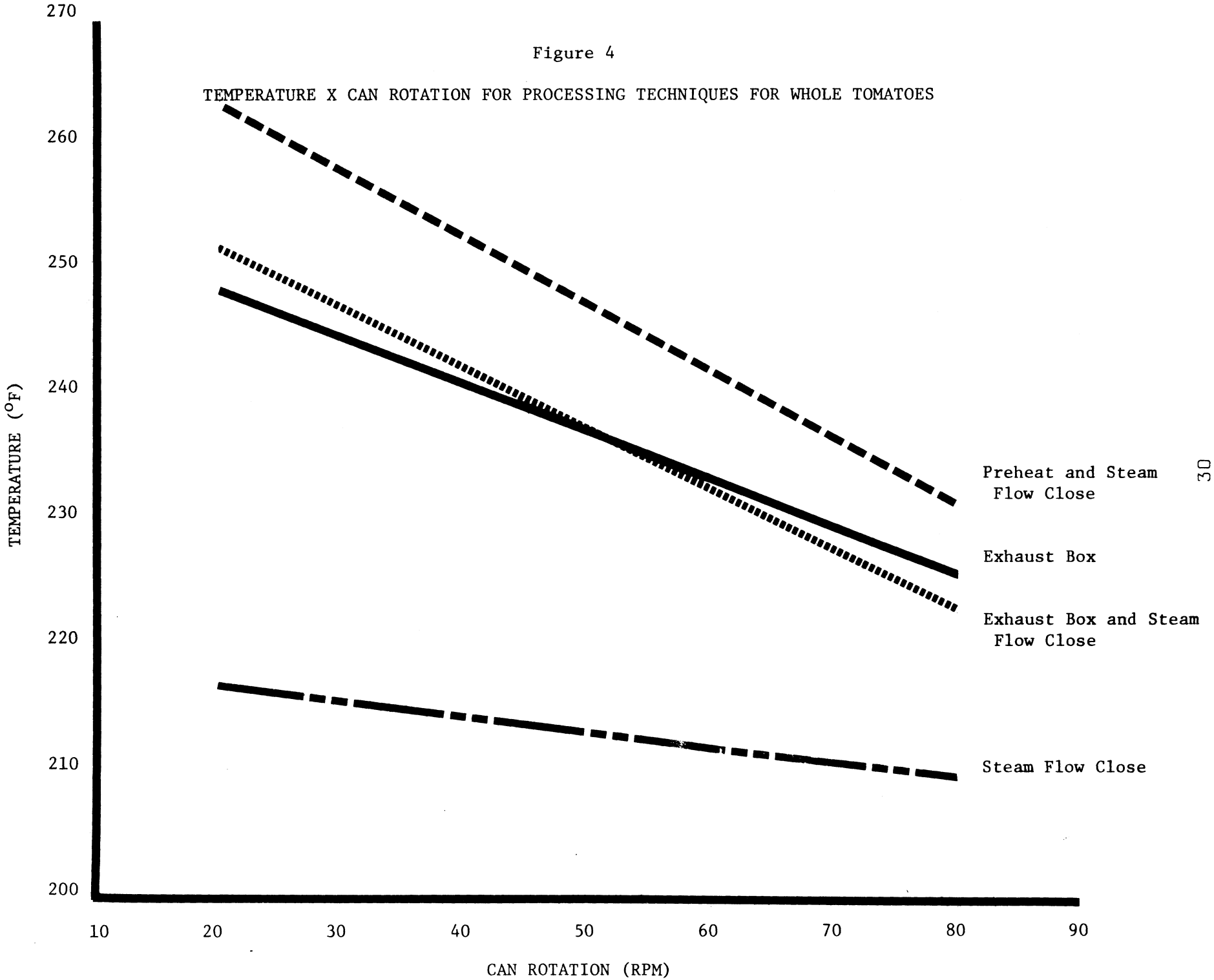
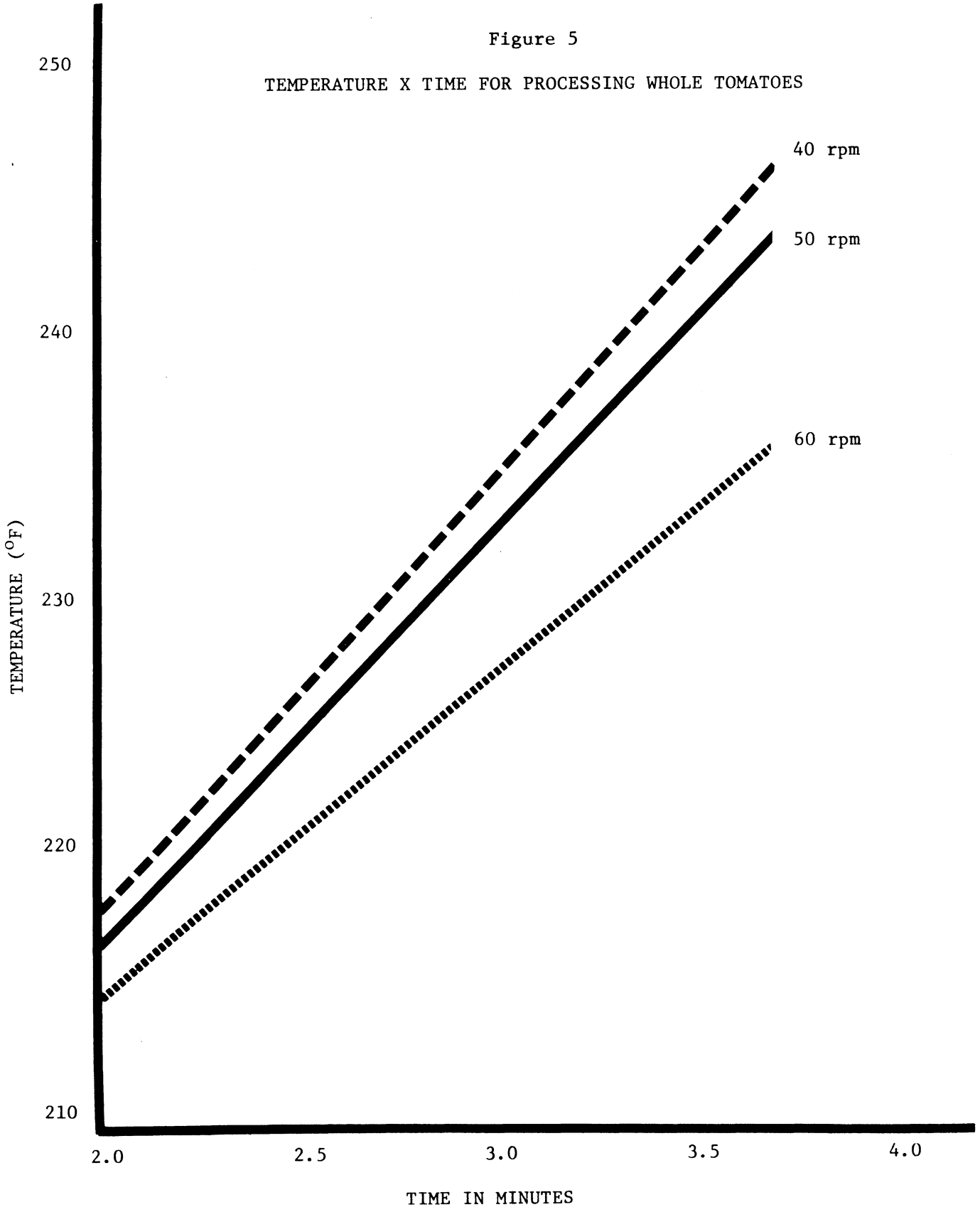


Figure 5

TEMPERATURE X TIME FOR PROCESSING WHOLE TOMATOES



A NEW SOYBEAN-BASED BEVERAGE

by

S. Badui and A. C. Peng

A beverage-type food is always enjoyed by all age groups, especially the youth. The most common beverages are milk or milk products or soft drinks which are either in scarce supply in the developing countries or low in calories or high in cost.

Soybean, the No. 1 cash crop, contains about 40% high quality protein whose nutritive value is considered the highest among other plant proteins; sesame with about 33% protein has high sulfur-containing amino acids, such as methionine and cystine; and cheese whey, a waste disposal headache, provides a superior protein (lactalbumin) and essential amino acids. By utilizing the above materials with a proper proportion and other food additives a new beverage type food has been developed in our laboratory.

An example of this product consisting of 5% full fat soybean, 4% sesame meal, 2% cheese whey, 1.5 to 2.0% corn sirup solids, small amount of carrageenan, salt, sugar and flavoring agent make a palatable and acceptable drink. If a defatted soybean flour is used, 1.5% of any edible oil, for instance, corn oil will be added back. A typical chemical compostion of such is 3.4% protein, 1.1% fat, 3.5% carbohydrates, and 0.6% minerals. Comparing its high sulfur concentration, 4.5% with 3.1% of soybean alone, it possibly indicates that a higher sulfur-containing amino acid content could be reached by additional sesame and cheese whey, especially sesame meal.

This experiment is considered a model system which can be modified to meet the availability of locally obtained raw materials.

CHANGES OF LIPID COMPOSITION DURING FERMENTATION FROM CABBAGE INTO SAUERKRAUT

by

A. C. Peng

Cabbage is one of the major vegetable crops in Ohio, and sauerkraut, the fermented product, is a popular food in our daily diet. Fermentation by lactic acid bacteria to preserve vegetables has been a traditional Chinese method. Pickles are another typical food from cucumbers. The main function of fermentation is to supply microorganisms the necessary energy for growth and metabolism from the substrate, therefore the chemical composition of the product is altered.

The purpose of this research is to investigate the changes in total lipids, lipid classes and their fatty acid composition in conjunction with organoleptic evaluation at predetermined intervals as related to their shelf life after fermentation, processing and storage. This report only covers the effect of fermentation and processing on total lipids and fatty acid composition.

Golden Acre Yellows Resistant cabbage (Brassica oleracea var. capitata L.) was fermented into sauerkraut. The kraut was canned, heat processed and stored at room temperature. Lipids were extracted by chloroform-methanol solution (2:1, v/v) and their classes were separated by column chromatography of silicic acid and Florisil. The fatty acid composition of each class was analyzed qualitatively and quantitatively by gas-liquid chromatography.

The total moisture for fresh cabbage was 92.57% and average 91.54% for the kraut. The total acidity was 1.43% and pH 3.35. A 0.16% was found for total cabbage leaf lipids whereas 0.22% was for the kraut. Their major fatty acids are presented in Table 1.

The data demonstrates a typical plant fatty acid pattern containing lauric, myristic, palmitic, stearic, oleic, linoleic and linolenic acids. The major changes after fermentation and processing are palmitic and linoleic acids in which palmitic acid was increased in total lipids, neutral lipids and glycolipids and decreased almost 50% in phospholipids; linoleic acid increased over 200% in neutral lipids, and linolenic acid decreased nearly 30% in phospholipids. The overall results from fermentation and processing show increase in unsaturated fatty acids.

Table 1

PERCENT FATTY ACID COMPOSITION OF CABBAGE AND SAUERKRAUT

Fatty Acid	Total Lipids		Neutral Lipids		Glycolipids		Phospholipids	
	Cabbage	Kraut	Cabbage	Kraut	Cabbage	Kraut	Cabbage	Kraut
12:0*	1.6	1.6	5.1	1.8	7.9	5.4	2.5	5.6
14:0	2.9	3.3	5.4	1.8	7.1	3.5	2.2	3.1
15:0	2.3	1.7	3.7	1.3	2.4	2.0	1.6	5.1
16:0	7.5	8.8	13.3	14.3	17.1	20.2	26.2	13.7
18:0	5.4	5.3	3.6	4.6	3.5	4.6	3.4	6.5
18:1	10.8	10.8	7.0	11.1	4.2	3.0	10.1	10.4
18:2	14.0	16.1	6.7	21.7	4.1	5.1	14.2	12.8
18:3	16.9	17.3	24.0	24.6	26.4	26.0	16.3	11.5

* Carbon number:number of double bonds

THE EFFECT OF CALCIUM, SULFITE AND ASCORBIC ACID DIPS AND STORAGE TEMPERATURE ON QUALITY OF APPLE SLICES (MELROSE AND GOLDEN DELICIOUS CULTIVARS) FOR PROCESSING INTO APPLE PIES

by

Manoranjan Kalia and W. A. Gould

Commercial apples are used extensively for prepared foods. A major portion of processed apples is in the form of slices for the pie trade. In addition, about 20.4 percent is canned, 3.0 percent dried, 4.9 percent frozen and 12.8 percent processed by other means.

This study was conducted in the Food Processing and Technology Pilot Plant of the Department of Horticulture during 1972-73. Two apple cultivars, Melrose and Golden Delicious, were included in the investigation. The apples were procured from the Ohio Agricultural Research and Development Center, Wooster, Ohio. The fruit was stored at a temperature of 34°F and 90 percent relative humidity for 3 months prior to processing following harvest.

Apples of uniform size were peeled and cored with the aid of Leader Mechanical Apple Peeler, trimmed and sliced radially into eight segments with a hand slicer. The slices were given six chemical treatments using chemically pure calcium chloride as a source of calcium, sodium sulfite as a source of sulfur dioxide and anhydrous ascorbic acid (Table I). The slices were dipped in the sulfite solution for one hour and in the calcium and ascorbic acid solutionsfor 30 minutes. Following the dipping, the slices were drained and approximately 1 pound of slices from each treatment was filled into polyethylene bags. The bags were vacuumed and hermetically sealed with the aid of the Griswork Vac-U-Seal machine, marked and stored at respective storage temperatures. The bags of slices were placed in 0°, 32° and 50°F storage.

After 3 weeks storage, at weekly intervals, samples from each storage were removed and immediately evaluated. After equilibrating at room temperature, they were baked into pies. The top crust was not used, however the pies were covered with aluminum foil. The baking was done at 425°F in a Dispatch Rotary Oven for 40 minutes. The slices of the apple pies from the various treatments were evaluated in terms of color, flavor, and texture by a trained panel of ten judges. Two randomly selected slices were evaluated for texture determination from each treatment. The texture was determined both on baked and unbaked slices with the FTC Texturemeter at each sampling period, which corresponded with the baking schedule.

Evidence, if any, of mold growth was observed in the slices of both cultivars under different treatments. The mold growth was seen on the upper surface of the slice in the beginning and subsequently it covered the whole slice in some instances. The slices treated with ascorbic acid were badly affected by mold. In addition, gas production was observed which forced open the hermetically sealed bags.

The texture of the slices kept at 0°F storage was soft, however the shelf life was maximum. The slices stored at 50°F showed rapid deterioration with a maximum of 21-28 days shelf life for both cultivars. The slices stored at 32°F showed no signs of deterioration up to 56 and 49 days respectively for Melrose and Golden Delicious cultivars. The texture of the slices decreased as the duration of storage increased, the trend was similar in cases of baked and unbaked slices of both cultivars. The slices of Golden Delicious were softer than the slices of Melrose, when compared for the same shelf life duration and same treatment.

In summary, the slices of Melrose cultivar were generally superior in terms of processing qualities (color, flavor and texture) to the slices of Golden Delicious cultivar. Usually higher scores for color and texture were given to the Melrose slices.

Among the three temperatures (0°, 32° and 50°F), better quality slices were obtained at 32°F at each sampling period. The best color retention was observed in the treatment of calcium (1.0%) and sulfur dioxide (0.1%), and the slices were firmer, both before and after baking. The frozen slices (0°F) had little or no visual color changes for the maximum storage of 63 days.

TABLE I -- CHEMICAL TREATMENTS

Treatment number	Chemical used	Concentration (% by weight)
1	Calcium and sulfur dioxide	0.5 0.1
2	Calcium and sulfur dioxide	1.0 0.1
3	Sulfur dioxide	0.1
4	Calcium and ascorbic acid	0.5 0.5
5	Calcium and ascorbic acid	1.0 0.5
6	Ascorbic acid	0.5

SALT FREE PROCESSING OF PICKLING CUCUMBERS

by

Jerry L. Shoup and W. A. Gould

Significant dollar losses have been incurred by the pickle processing industry due to soft and bloating or hollow pickles formed during the brining process. Also both the industry and government agencies have recognized the need for alternative methods for disposal of spent brines wihout causing water pollution. To alleviate some of these problems, the feasibility of processing pickles in various acid solutions without salt is being investigated.

Large size cucumbers (1 7/8 - 2 1/8 in.) highly susceptable to bloating from mixed cultivars were obtained from the H. J. Heinz receiving station in Fremont, Ohio. The cucumbers were divided into appropriate lots and covered with the following treatments: acetic (4.5%), lactic (1%), citric (1%), a 2:1 blend of acetic and lactic, and a 2:1 blend of acetic and citric. Each treatment received a 0.1 percent potassium sorbate as a preservative. Following acidulant and cucumber equilibration, the fermentation containers were sealed and the headspace flushed with nitrogen. Standard salt brine controls were prepared by covering with a 40 degree salometer brine.

At two and four month intervals appropriate samples were withdrawn and analyzed. Bloater damage was evaluated by slicing 40 pickles and recording the type and number of bloaters in the sample lots. Firmness was measured with a USDA fruit pressure tester (5/16 in. tip) by recording the pounds resistance to center punch from 20 sample pickles.

This project is being continued and samples will be evaluated at 6 and 8 month intervals.

From the data in Table I and Figure 1, it appears as though there is a substantial reduction in the extent of bloater damage between the salt control and acetic acid treatments. The citric acid samples produced the highest number of bloaters reaching 100 percent at the 4 month analysis period.

From the data in Figure 1, it can be seen that the salt control yielded the highest percentage of non-balloon type bloaters. It should be noted that in all of the acidulant treatments except for lactic and citric, the balloon bloaters were smaller and less significant than the salt control. Generally, the percent bloater damage increased between the two analysis periods.

The data in Figure 2 shows the pounds resistance to puncture the pickles with the pressure tester. During both analysis periods the values for the acetic acid treatment were higher than the control. Further, there appears to be a substantial reduction in firmnesss with the lactic and citric treatments after 4 months storage. All treatments displayed a decrease in texture between the two and four month storage periods.

Table I - Bloater Damage Evaluation

Treatment	Sample Period	No. Cut	Balloon Type	Lens Type	Honeycomb Type	Total No.	Total %
Salt Control	2 mo.	40	18	1	7	26	65
	4 mo.	40	25	1	4	30	75
Citric	2 mo.	40	35	0	1	36	90
	4 mo.	40	39	0	1	40	100
Lactic	2 mo.	40	30	1	1	32	80
	4 mo.	40	32	0	0	32	80
Acetic & Citric	2 mo.	40	18	0	2	20	50
	4 mo.	40	31	0	1	32	80
Acetic & Lactic	2 mo.	40	21	0	3	24	60
	4 mo.	40	33	0	1	34	85
Acetic	2 mo.	40	2	0	1	3	7.5
	4 mo.	40	10	1	0	11	27.5

Figure 1 - Percent Bloaters 2 and 4 Months Storage

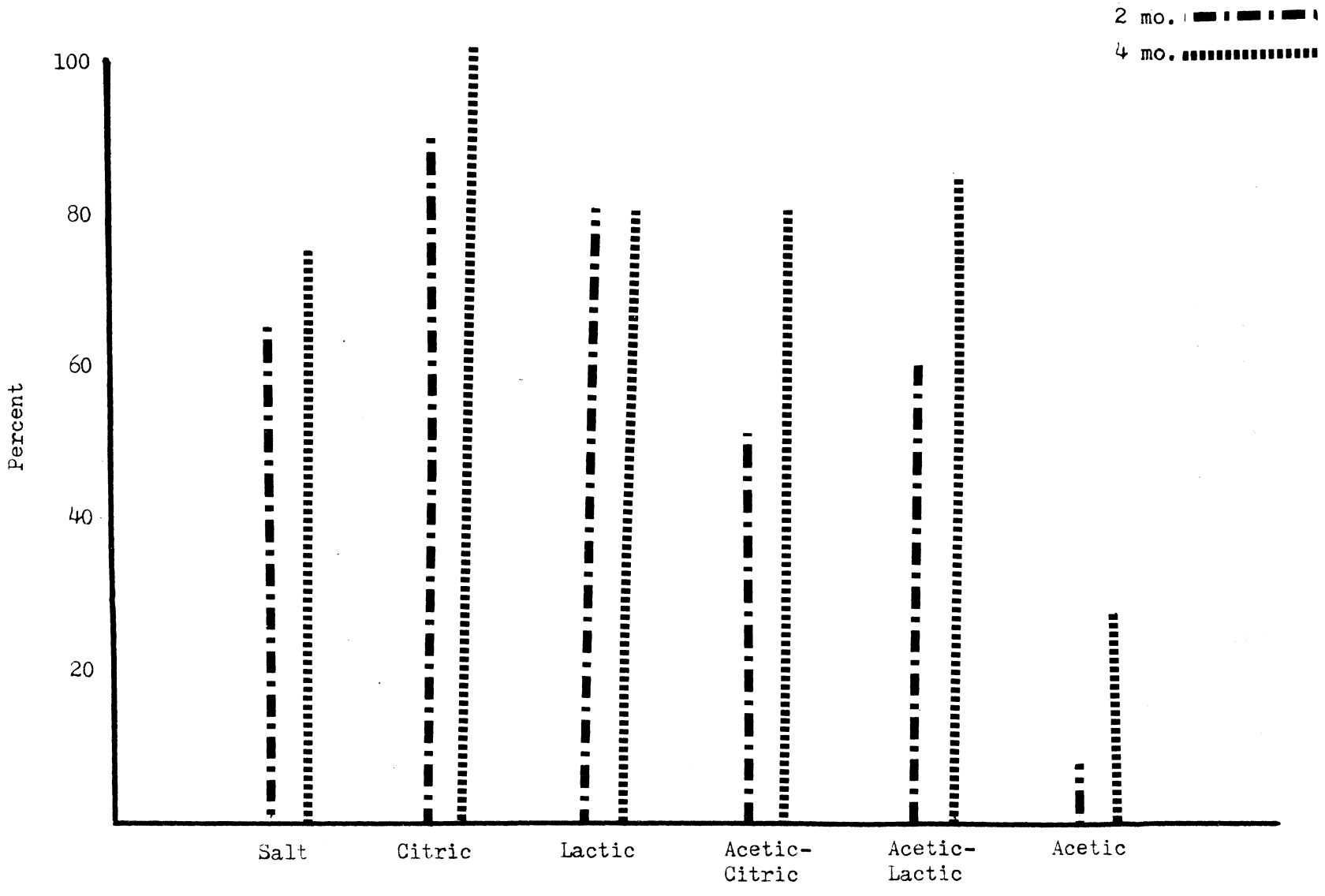
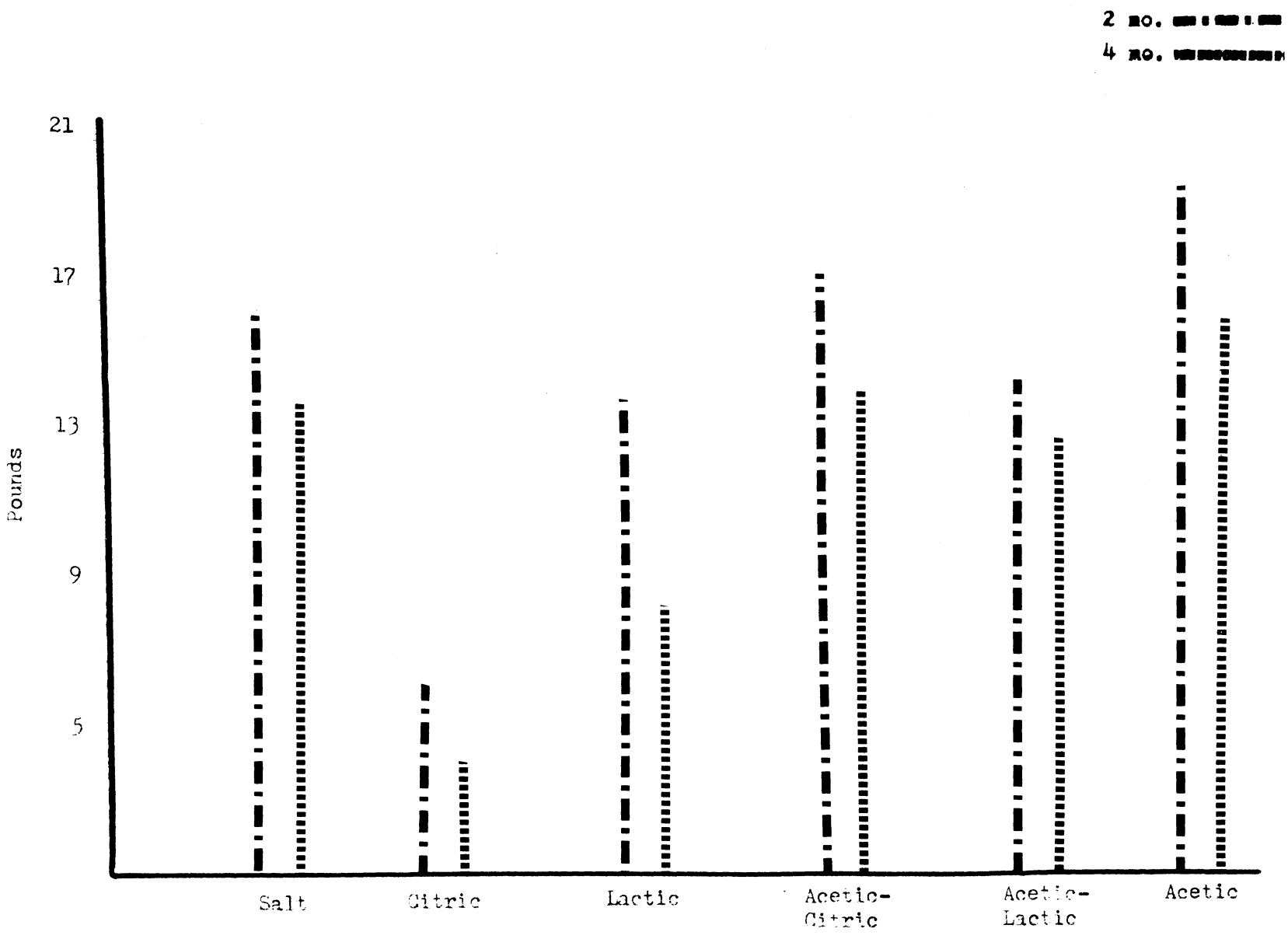


Figure 2 - Pounds Resistance 2 and 4 Months Storage



NUTRIENTS IN HORTICULTURAL PRODUCTS

by

D. E. Crean

A problem confronting the food processor in the early 1970's is that of nutrient labelling. Broadly, this requires food processors to report, on the label, percentages of the Recommended Daily Allowance (RDA) of certain nutrients as they occur in representative servings of the food. This raises a problem for the small processor since not only must he be aware of the RDA for each nutrient (which has recently undergone revision), decide on what constitutes a serving and be aware of what nutrients are present in significant quantities in his product; but, he must also know with a fair degree of precision what the nutrient composition is.

Such composition is extremely variable, being affected not only by the type of product, but also by such factors as variety, maturity, climatic and clutural factors and process variables. Accordingly, samples of the particular product need to be analyzed throughout the season and, since this requires sophisticated analytical techniques such as fluorometry and atomic absorption spectrophotometry, this is generally carried out by independent analytical laboratories whose fees for the mandatory package range from $150 to $180 (2).

The Department of Horticulture of The Ohio State University is seeking to evaluate some of the factors affecting nutrient composition in horticultural crops. In preparing a research proposal, it was necessary to determine approximately the levels of nutrients in selected items, processed and unprocessed. Accordingly, data were obtained from the USDA Handbook No. 8 (3) and recalculated in terms of RDA. Admittedly, this source is not recognized by the FDA and food processors cannot simply recalculate these data and print these data on the label. However, it was felt that such data might be of interest to Ohio food processors and they are thus presented here.

The data are presented as percentage of RDA for a six ounce serving except in the case of calories where total calories per six ounce serving are reported. The RDA for the mandatory vitamin and mineral package are presented in Table 1 which represents the latest information available to the author (1). In all cases where the RDA's differed, the higher value was selected as a basis for calculation.

The guidelines for nutrient labelling are such that any nutrient source better than 10% RDA is regarded as a significant source of that nutrient. The nutrient, if added, is a dietary supplement if it is over 50 but less than 150 percent of the RDA. If the nutrient is over 150 percent it may be considered a drug.

It is obvious that most processed vegetables are a significant source of Vitamin C and Vitamin A. Fruits with the exception of peaches and strawberries do less well. The high amount of ascorbic acid in frozen peaches, however, reflects its status because of an added antioxidant.

As far as the B vitamins are concerned, vegetables are suprisingly good sources. Frozen broccoli, sweet corn, french fried potatoes, spinach and canned and frozen peas are significant sources of the B vitamins.

Table 1

RECOMMENDED DAILY DIETARY ALLOWANCES FOR CERTAIN NUTRIENTS

	Vit. A (I.U.)	Thia-mine (mg)	Ribo-flavin (mg)	Niacin (mg)	Ascorbic Acid (mg)	Calcium (mg)	Iron (mg)
Males 23-50	5000	1.4	1.6	18	45	800	10
Females 23-50	4000	1.0	1.2	13	45	800	18

Most of these figures, with the exception of Vitamin A and Iron, have been revised downward from previous figures. The most notable case has been that of Ascorbic Acid (Vitamin C) in which the RDA has been reduced by 25% from 60 to 45 mg/day.

Table 2

NUTRIENT CONTENT OF RAW VEGETABLES PER 6 OZ. SERVING

	Cal.	% RDA						
		Vit. A	Thia-mine	Ribo-flavin	Niacin	Ascorbic Acid	Calcium	Iron
Asparagus	44	31	22	21	14	125	5	19
Beans, Lima	209	10	29	13	13	110	11	26
Beans, Snap	54	20	10	12	5	72	12	8
Beets	73	--	3	5	4	38	3	7
Broccoli	54	85	12	24	8	425	22	10
Carrots	71	375	7	5	6	30	8	7
Corn, Sweet	163	14	18	13	16	45	--	7
Peas	143	22	42	15	27	102	5	18
Potatoes	129	--	12	4	14	75	--	6
Spinach	44	275	12	21	5	193	20	29
Tomato	37	31	7	4	6	87	3	5

Table 3

NUTRIENT CONTENT OF PROCESSED VEGETABLES PER 6 OZ. SERVING

	Cal.	% RDA						
		Vit. A	Thia-mine	Ribo-flavin	Niacin	Ascorbic Acid	Calcium	Iron
FROZEN FOODS								
Beans, Lima	174	8	12	6	11	83	5	18
Beans, Snap	44	20	9	11	4	34	9	8
Broccoli	48	65	9	14	6	295	9	7
Corn, Sweet	139	12	13	7	15	30	--	8
Peas	124	23	39	11	19	72	4	19
Potatoes, FF	289	--	17	--	20	76	--	13
Spinach	43	275	12	17	5	132	22	24
COOKED, DRAINED FROZEN FOODS								
Beans, Lima	168	8	9	5	9	64	4	16
Beans, Snap	43	20	9	10	4	19	9	7
Broccoli	44	65	7	12	5	275	9	7
Corn, Sweet	134	12	11	6	14	19	--	8
Peas	116	20	33	10	16	49	4	18
Potatoes, FF	374	--	17	--	25	79	--	17
Spinach	41	275	10	15	5	106	22	24
CANNED FOODS								
Asparagus	36	27	7	11	8	57	4	18
Beans, Snap	41	16	4	5	3	15	10	14
Beets	63	--	--	3	--	31	4	7
Carrots	51	500	--	3	4	8	6	7
Corn, Sweet	143	12	4	5	9	15	--	5
Peas	150	23	11	6	8	30	6	18
Tomatoes	36	31	6	3	7	64	--	5
Tomato Juice	32	27	6	3	8	60	--	9

Table 4

NUTRIENT CONTENT OF RAW AND PROCESSED FRUITS PER 6 OZ. SERVING

	Cal.	% RDA						
		Vit. A	Thia-mine	Ribo-flavin	Niacin	Ascorbic Acid	Calcium	Iron
RAW FRUITS								
Apples	99	3	3	--	--	15	--	3
Cherries, sour	99	34	6	6	3	38	5	4
Cherries, sweet	119	4	6	6	3	38	5	4
Grapes	117	3	6	3	3	15	3	4
Peaches	65	45	--	5	9	26	--	5
Pears	104	--	--	4	--	15	--	3
Strawberries	63	--	3	7	6	225	4	9
PROCESSED FRUITS								
Applesauce	155	--	--	--	--	4	--	5
Cherries, sour, canned	125	22	4	--	--	19	3	3
Cherries, sweet, canned	110	--	--	--	--	11	3	3
Grape juice	112	--	5	--	--	--	--	3
Peaches -								
canned	133	15	--	--	6	11	--	3
frozen	150	22	--	4	7	150	--	5
Pears, canned	104	--	--	--	--	4	--	--
Strawberries, frozen	185	--	--	6	5	200	3	7

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MAPLE SAP CONCENTRATION BY REVERSE OSMOSIS

James F. Gallander

In recent years, there has been increased interest in applying reverse osmosis to the removal of water from food products. This process is a relatively recent development which is characterized by exerting pressure in excess to the osmotic pressure to force water through a selective membrane. Since reverse osmosis concentration avoids heating or any phase change, the process appears to have promise for economy and quality retention in concentrating several food products.

One of the more successful applications of the reverse osmosis process in the food industry has been the concentration of maple sap as an intermediate step in the production of maple syrup (2,3). For these studies, spiral-wound cellulose acetate membranes were used in the construction of the EUROC (Eastern Utilization Reverse Osmosis Concentrator). Maple sap was successfully concentrated from 2.5 to 7.5 Brix. This unit removed about 75% of the water at 4% of the energy cost of the common fuel used in the conventional boiling procedure.

Although the EUROC unit was successful in concentrating sap, the problem of maintaining the unit in good sanitary condition was observed during continuous operation (1). This unit operates as a closed system which presents a problem of draining and disassembling for sanitizing purposes.

Because the EUROC unit has a sanitizing problem, a study was initiated at the OARDC to determine the feasibility of concentrating maple sap by a tubular type reverse osmosis unit. The successful application of the tubular type reverse osmosis unit with good sanitation design would be a benefit to the maple syrup industry. Not only would the thermal energy required for processing be reduced, but longer periods of continuous operation may be obtained by using tubular type units.

Materials and Methods

Maple sap from species *Acer saccharun* Marsh was collected during the spring of 1972. After each sap flow, the sap was collected and placed in frozen storage (-15° F.) until further processing. When sufficient quantity of sap was obtained, the sap was thawed and the Brix (sugar content) was determined at 20° C.

This maple sap (1.8° Brix) was passed through each of three tubular modules (#400, #500 and #600) from Havens International,San Diego, Calif., at four different flow rates (350 to 2500 ml./min.). The pump pressure was maintained at 600 psi and the Brix of the product was determined after each test. In addition, Maple sap was passed through the relatively loose module (#400) two consecutive times at 600 psi. The flow rate for this test was 700 ml./min.

Results and Discussion

The Brix of the concentrated maple sap at different flow rates and from three membranes are given in Table 1.

TABLE 1. - Change in Brix of Concentrated Maple Sap as Related to Various Membranes and Flow Rates

Flow Rate (ml./min	Brix of Maple Sap from three membranes		
	#400	#500	#600
350	3.8	3.4	2.8
700	3.0	2.4	2.2
1400	2.4	2.1	2.1
2500	2.0	2.0	2.0

Maple sap of lowest degrees Brix, when pumped at 600 psi., was obtained at the highest flow rate (2500 ml./min.). This concentration was 2.0° Brix and was observed for all three membranes (#400, #500, and #600). As the flow rate was decreased, the degrees Brix of the maple sap was increased for each membrane. The greatest concentration occurred when the sap was passed through the least dense membrane (#400) at the lowest flow rate (350 ml./min.). The maple sap was concentrated from 1.8° to 3.8° Brix. In contrast, the lowest concentration (2.8° Brix) occurred when the sap was passed through the #600 membrane at the lowest flow rate.

The results of passing maple sap (1.8° Brix) through a relatively loose membrane (#400) two consecutive times at 600 psi are given in Table 2. The flow rate was 700 ml./min. and the sap was concentrated to 4.3° Brix for the first pass. During the second pass through the membrane, the concentrated maple sap was increased to 7.6° Brix and more than 75 percent of the water was removed during the two passes.

TABLE 2. - Change in Brix of Maple Sap with Two Passes Through #400 Membrane at 600 psi and a Flow Rate of 700 ml./min.

Number of Passes	Brix of Maple Sap
0	1.8
1	4.3
2	7.6

Summary

Based on the results of this study, reverse osmosis concentration with tubular membranes was effective in removing water from maple sap. Further studies are needed to establish good sanitary conditions for this unit under commercial operations.

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